Fishery Data Series No. 02-11

Evaluation of Stocked Game Fish in the Tanana Valley, 2000

by
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and
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July 2002

Alaska Department of Fish and Game **Division of Sport Fish**

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used in Division of Sport Fish Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications without definition.

Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
metric ton	mt
milliliter	ml
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

All commonly accepted abbreviations.	e.g., Mr., Mrs., a.m., p.m., etc.
All commonly accepted professional titles.	e.g., Dr., Ph.D., R.N., etc.
and	&
at	@
Compass directions:	
east	E
north	N
south	S
west	W
Copyright	©
Corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
et alii (and other people)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.,
id est (that is)	i.e.,
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
number (before a number)	# (e.g., #10)
pounds (after a number)	# (e.g., 10#)
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S. state and District of Columbia abbreviations	use two-letter abbreviations (e.g., AK, DC)

Mathematics, statistics, fisheries

alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	F, t, χ^2, etc.
confidence interval	C.I.
correlation coefficient	R (multiple)
correlation coefficient	r (simple)
covariance	cov
degree (angular or temperature)	°
degrees of freedom	df
divided by	÷ or / (in equations)
equals	=
expected value	E
fork length	FL
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_{2}$, etc.
mideye-to-fork	MEF
minute (angular)	'
multiplied by	x
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
standard length	SL
total length	TL
variance	Var

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ABSTRACT

A two-sample mark-recapture experiment was conducted at Dune Lake to estimate the abundance and size structure of the rainbow trout population. Estimates of abundance by size category were 295 (SE=57) fish 350 to <480 mm FL; 146 (SE=32) fish 480 to 520 mm FL; and 30 (SE=10) fish >520 mm FL. The size range was 420 to 621 mm FL.

Three lakes near Delta Junction were identified as candidates for special management to promote fisheries for large rainbow trout. Abundance and size structure of each population was estimated with two-sample mark-recapture experiments. This information along with limnological characteristics will be used to evaluate each lake's potential to produce large fish. Estimates of rainbow trout abundance for Bluff Cabin Lake was 909 (SE=74) fish >250 mm FL. In Donna Lake estimates of rainbow trout abundance were 1,916 (SE=258) fish <355 mm FL and 154 fish (SE=31) ≥355 mm FL. Estimates of rainbow trout abundance for Little Donna Lake were 1,454 (SE=425) fish <355 mm FL; 184 (SE=62) fish ≥355 to <460mm FL; and 13 (SE=10) fish ≥460 mm FL.

Key words: Dune Lake, Bluff Cabin Lake, Donna Lake, Little Donna Lake, rainbow trout, *Oncorhynchus mykiss*, coho salmon, *Oncorhynchus kisutch*, trophy, large, stocking evaluation, stock assessment, stocking method, length at age, mark-recapture, harvest, special management.

INTRODUCTION

The Alaska Department of Fish and Game (ADF&G) stocks game fish in numerous lakes and one stream in the Tanana River Valley within Alaska's interior (Figure 1). Our goal is to provide diverse and dependable angling opportunities near population centers and offer more alternatives to the harvest of wild stocks. The stocking program began in the early 1950s, when lakes along the road system were stocked with rainbow trout *Oncorhynchus mykiss*, or coho salmon *O. kisutch*. Today, the stocking program provides dependable year-round sport-fishing opportunity for rainbow trout, coho salmon, chinook salmon *O. tshawytscha*, Arctic grayling *Thymallus arcticus*, Arctic char *Salvelinus alpinus*, and lake trout *S. namaycush*.

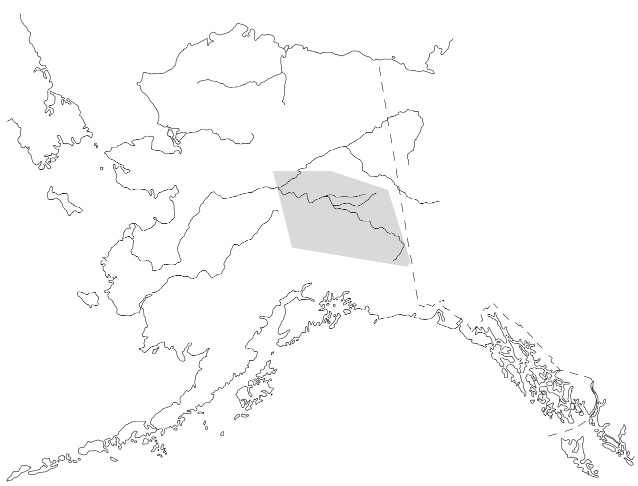

Figure 1.-The Tanana Valley (shaded area).

The stocking program supports consumptive fisheries along the road system where fishing effort and harvest are highest. As a conservation measure, it serves to divert harvest away from wild populations. In 1999, an estimated 30,833 anglers fished in the Tanana Valley, and they generated an estimated 160,427 angler-days of effort[1] (Howe et al. 2001d). An estimated 63,061 angler-days of effort was directed toward stocked fish. The estimated harvests of stocked and wild fish in the Tanana Valley in 1999 were 66,123 and 20,890, respectively. Since 1990, stocked fish have represented 51 to 75% of the total estimated harvest of game fish in the Tanana Valley and about 33 to 44% of the total estimated fishing effort. In 1999, about 68% of the total harvest of wild and stocked fish in the Tanana Valley was attributed to just two stocked species: rainbow trout and landlocked coho salmon (Howe et al. 2001d).

A healthy and diverse stocking program is important to anglers and businesses in the Tanana Valley where most wild fish populations can not support the level of consumptive use desired by anglers. It also provides opportunity to catch highly valued species such as rainbow trout and Arctic char that are not native to the Tanana Valley. Only a few lakes in the Tanana Valley produce rainbow trout larger than 600 mm and anglers have requested that the department manage some lakes specifically to promote production of large rainbow trout and to maintain adequate numbers for an attractive fishery.

The purpose of the following studies was to obtain current information on the status of rainbow trout populations in four lakes in the Tanana Valley. This information will be used by fishery managers to assess possible management concerns at Dune Lake and to evaluate three lakes as candidates for special management as fisheries for large rainbow trout.

ABUNDANCE AND COMPOSITION OF RAINBOW TROUT IN DUNE LAKE

An increasingly popular rainbow trout fishery exists at Dune Lake. Anglers have expressed concern that the fishery has declined in recent years. They have noticed the number of large rainbow trout available for harvest has declined. Currently, ADF&G does not know if this decline is due to increased harvests, poor survival of stocked fingerlings, or some other cause. Dune Lake is approximately 40 km west-southwest of Nenana, between the Nenana and Kantishna rivers (Figure 2). The lake surface area is 72 ha and maximum depth is about 7 m (Figure 3). During summer the lake is reached by light aircraft with floats and winter access is by snow machine along a 56 km trail. No wild fish populations exist in Dune Lake. The fishery is maintained entirely by stocking hatchery reared rainbow trout, coho (silver) salmon, and Arctic grayling. No evidence of natural reproduction has been found. Since 1990, rainbow trout have been stocked on odd years (Appendix A1). The average size of rainbow trout when stocked ranged from 50 to 75 mm. Coho salmon and Arctic grayling have been stocked on even years (Appendix A1). This stocking strategy is employed to reduce the cost of transporting all three species by aircraft every year to Dune Lake.

In response to anglers' observations that there was a recent decline in the number of large rainbow trout, ADF&G conducted a mark-recapture experiment to estimate the abundance and size structure of rainbow trout in Dune Lake during summer 2000. Prior to 2000, the department had not directly examined the Dune Lake fishery and had no information on abundance or structure of the fish populations. Estimates of the number of anglers, effort, catch, and harvest for Dune Lake, however, have been obtained through a statewide mail-out survey since 1986.

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[1] Fishing effort (angler-days) for a location is defined as the estimated number of days fished by all anglers for that location (Mills 1990-1994; Howe et al. 1995, 1996, 2001a, b, c). Any part day fished by an angler is considered one angler-day.

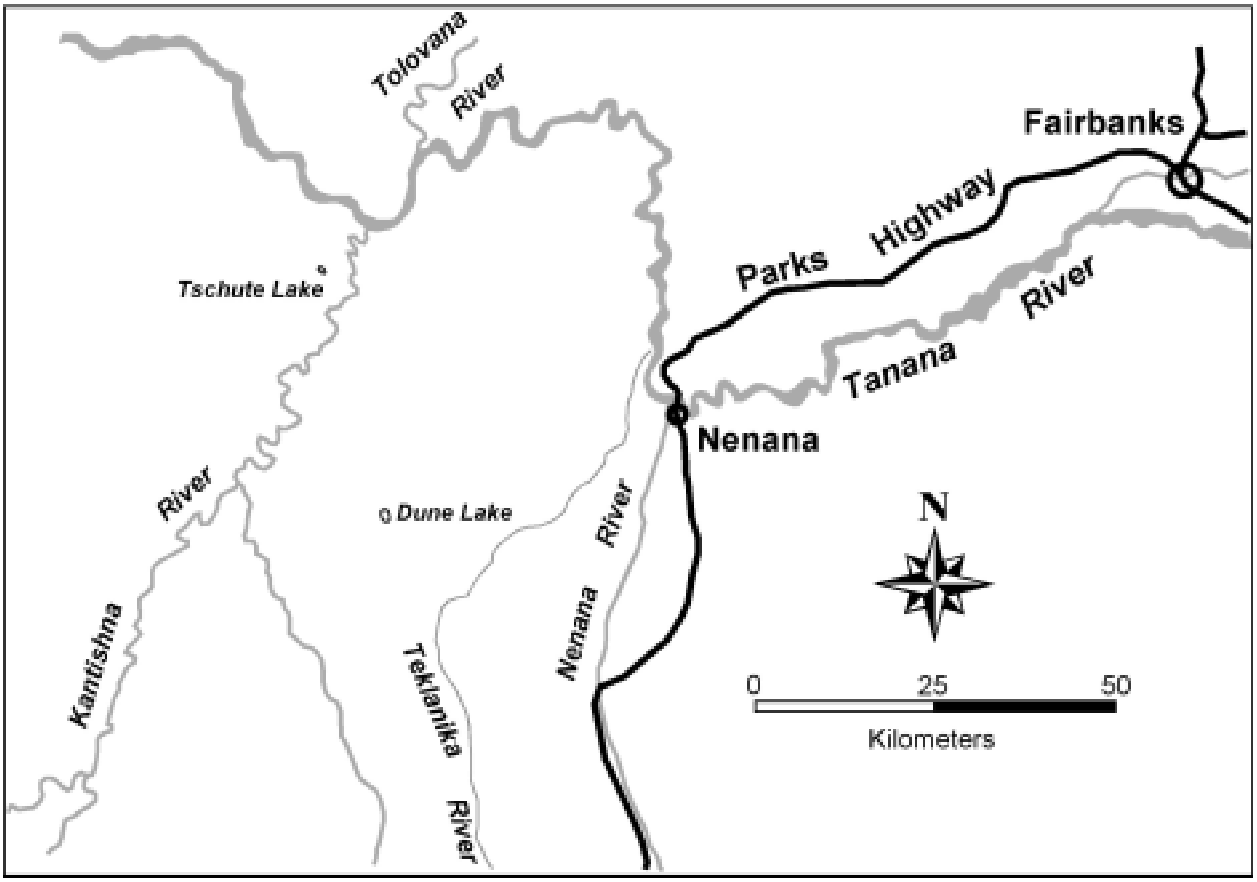

Figure 2.-Location of Dune Lake in the Tanana Valley.

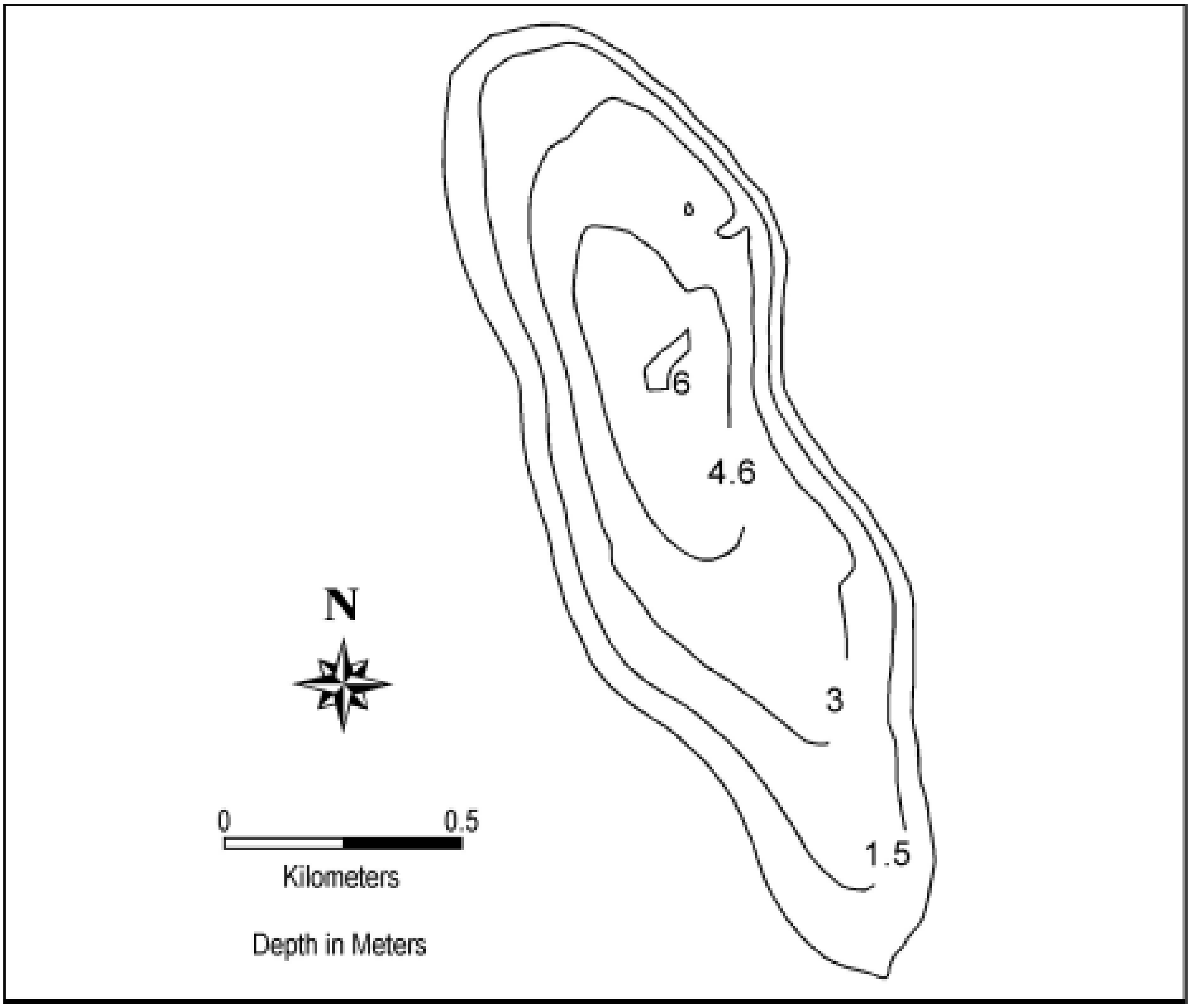

Figure 3.-Dune Lake.

FISHERY STATISTICS

In 1999, an estimated 595 anglers generated 908 angler-days of effort (Table 1; Figure 4). Catch and harvest of all stocked species were 6,664 and 2,878, respectively. An estimated 4,603 rainbow trout were caught and 2,006 were harvested. This is the second highest annual number of rainbow trout caught in Dune Lake on record, and the harvest is more than double the recorded harvest since 1990. The catch and harvest for landlocked coho salmon were 1,359 and 443; and for Arctic grayling the catch and harvest were 702 and 429.

From 1990 to 1999, the total annual effort on all stocked species in Dune Lake ranged from 522 to 912 angler-days and averaged about 765 angler-days. Average annual effort per surface acre for stocked species is about 4.3 angler-days. Since 1990, 52% of the catch and 49% of the harvest of stocked game fish was made up of rainbow trout. Landlocked coho salmon were next significant in numbers of fish caught and harvested, followed by Arctic grayling. The average catch rate (catch / effort) at Dune Lake was about 7.2 fish per angler-day of effort. The annual cost of producing and stocking fish (stocking cost) in Dune Lake ranged from about $1,322 to $10,262, while the cost-per-day of fishing (stocking cost / effort) ranged from $2.24 to $11.25.

Current daily bag and possession limits for Dune Lake are:

Species	Daily Bag and Possession Limit	Size Limit
Rainbow trout	10	No size limit
Landlocked coho salmon	10	No size limit
Arctic grayling	5	No size limit

OBJECTIVES

The objective of this study was to estimate the abundance and size composition of the rainbow trout population in Dune Lake. Specific objectives were:

Management Objective: Determine the abundance of rainbow trout by size categories in Dune Lake.

Research Objective 1: Estimate the abundance of rainbow trout in Dune Lake, such that $\Pr\left(\left|\frac{\hat{N}-N}{N}\right| \geq 0.25\right) = 0.05$.

Research Objective 2: Estimate the size composition of rainbow trout in Dune Lake, such that $\Pr(|\hat{P} - P| \geq 0.05) = 0.05$.

Where P is the proportion of the population comprised of fish by size category. Size categories are: < 355 mm, 355 to 460 mm, and > 460 mm. These size categories correspond to < 14”, 14”–18”, and > 18”.

METHODS

A two-sample mark-recapture experiment was used to estimate the abundance of rainbow trout. Capture gear consisted of fyke nets, tangle nets, and sport-fishing gear. Six fyke nets were distributed roughly equidistance around the lake perimeter. Fyke nets were set near shore in 1 to 2 m of water and they rested on the lake bottom. The body of each fyke net was positioned parallel to shore. Wings connected to both sides of the open end were set to form a "V". One

Table 1.-Effort, harvest, and catch statistics by species for Dune Lake 1990-1999.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Effort										
Number of Anglers	625	613	623	412	557	494	607	441	349	595
Number of Days Fished (effort)	815	759	854	587	744	851	912	695	522	908
Catch										
Rainbow trout	2,144	1,230	2,304	3,060	2,207	4,789	3,898	2,594	1,846	4,603
Coho/Chinook salmon	1,182	1,999	443	437	294	2,067	2,542	2,069	2,048	1,359
Arctic grayling	1,502	1,541	992	706	2,560	507	1,594	1,075	525	702
Total	4,828	4,770	3,739	4,203	5,061	7,363	8,034	5,738	4,419	6,664
Harvest										
Rainbow trout	591	646	166	293	959	653	808	526	378	2,006
Coho/Chinook salmon	422	924	238	300	67	402	851	466	518	443
Arctic grayling	304	587	166	89	702	78	291	67	23	429
Total	1,317	2,157	570	682	1,728	1,133	1,950	1,059	919	2,878
Mean catch rate	5.9	6.3	4.4	7.2	6.8	8.7	8.8	8.3	8.5	7.3
Stocking cost						$3,667	$10,262	$2,037	$1,322	$2,037
Cost-per-day of fishing						$4.31	$11.25	$2.93	$2.53	$2.24
Cost-per-fish caught						$0.50	$1.28	$0.36	$0.30	$0.31
Cost-per-fish harvested						$3.24	$5.26	$1.92	$1.44	$0.71

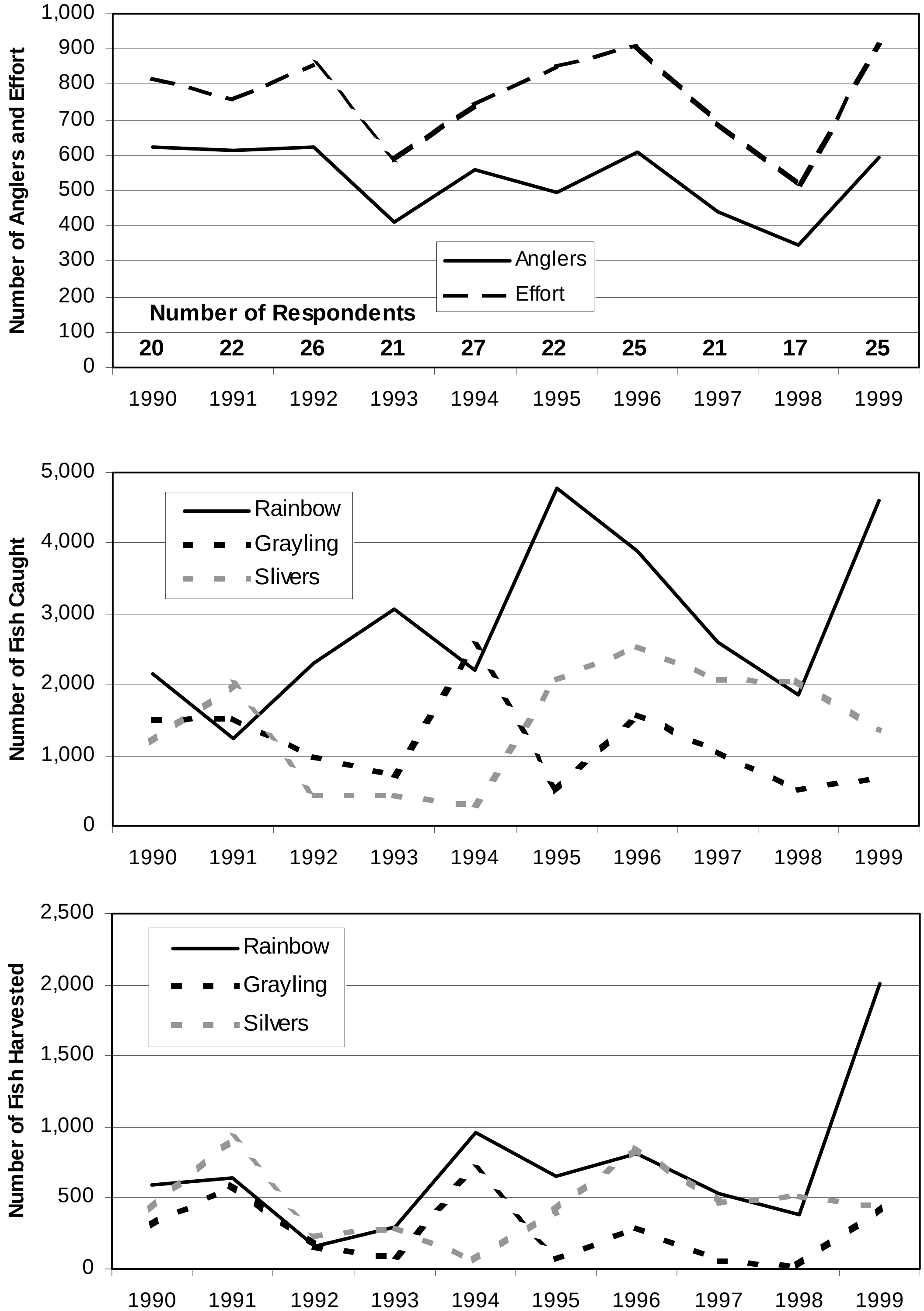

Figure 4.-Number of anglers, fishing effort (angler-days), and number of fish caught and harvested from Dune Lake, 1990-1999.

wing was anchored to shore and a weight was attached to the other wing and positioned offshore. Each fyke net was pulled taut from the cod end which was weighted. Fyke nets were checked every 24 hrs. The open end of a fyke net was either 0.9 or 1.2 m^2, hoop size was 0.9 m diameter, and mesh size was 9 mm^2. The wings were 7.5 m long by 1.2 m deep.

Tangle nets were 45 m (150 ft) long by 5.4 m (18 ft) deep, and were made of 13 mm (½ in) bar fine thread monofilament. Mesh size was small to ensure that fish were captured by entanglement around the mouth and not by the gill covers. One tangle net was a "floater" - the float line floated on the surface and the lead line was suspended 5.4 m below the surface. The other tangle net was a "sinker" – the lead line rested on the lake bottom and the float line was suspended 5.4 m above the lake bottom. The floater had a triple float line and 30 lb lead line. The sinker had a double float line and a 70 lb lead line. Tangle nets were usually set either parallel or perpendicular to shore, in water 3 to 7 m deep. The tangle nets were moved to various locations to ensure sampling canvassed all habitat types. Tangle nets were set for one-half hour to one hour. Tangle nets were used between 1200 to 1800 hrs.

Sport fishing gear consisting of artificial flies, lures, and bait was used between 0600 and 2400 hours. Anglers moved to a new location every 1/2 to 1 hour. Sampling effort with all gear types (fyke nets, tangle nets, and sport fishing gear) covered near shore and off shore water and the entire water column.

Each captured fish was marked with a fin clip and/or hole punch to identify the event in which it was captured and the capture gear. During Event 1, all fish received a half-hole punch in the trailing edge of the lower lobe of the caudal fin. During Event 2, all captured fish were marked with a half-hole punch in the upper lobe of the caudal fin. During both events each fish was given a second mark to identify the capture gear: a left ventral fin clip was given to fish captured in fyke nets; a right ventral fin clip was given to fish captured in tangle nets, and an adipose fin clip was given to fish captured with sport gear. If a fish was captured more than once during either event, it was not given additional marks but it was noted. All finclips removed only the distal 1/3 to 1/2 of the ventral or adipose fin. Our intent was for the mark to be recognizable during the experiment but for the fins to eventually grow back. All captured fish (rainbow trout, coho salmon, and Arctic grayling) were measured to the nearest millimeter FL. In this report, all fish-length measurements are FL unless noted otherwise. Scale samples were collected from a subset of all fish captured during June representing the size range of each species (rainbow trout and coho salmon). During the experiment, fish were subjectively categorized as "small", "medium", and "large" using length as the criterion. Scales were collected from 10 fish in each size category and three scales were taken from each fish using standard procedures for collecting scales from salmonids (Welander 1940). Fish age was determined from scale patterns using methods described by Mosher (1969).

The assumptions necessary for accurate estimation of abundance in a closed population and the testing of these assumptions are described in Appendices B and C. Depending on the outcome of these tests, we made appropriate adjustments as outlined in Appendix C.

Chapman's modification of the Petersen estimate (Chapman 1951; Seber 1982) was used to estimate the abundance of the rainbow trout population (≥ 300 mm):

$$\hat{N} = \frac{(n_1+1)(n_2+1)}{(m_2+1)} - 1 \tag{1}$$

where: $\hat{N}$ = the abundance of rainbow trout in a lake; n_1 = the number of rainbow trout marked and released during the marking event (Event 1); n_2 = the number of rainbow trout examined for marks during the recapture event (Event 2); and, m_2 = the number of marked rainbow trout recaptured in the recapture event. If a fish was captured more than once during a sampling event the subsequent capture(s) was noted in our records but it was not measured nor was the subsequent capture(s) used in data analysis or estimation of abundance.

Variance of this estimator was calculated using (Seber 1970; Wittes 1972):

$$V\left[\hat{N}\right] = \frac{(n_1+1)(n_2+1)(n_1-m_2)(n_2-m_2)}{(m_2+1)^2(m_2+2)}. \quad (2)$$

RESULTS AND DISCUSSION

During Event 1 (11 - 15 June), 171 rainbow trout larger than 300 mm were captured, marked, and released. The average size of rainbow trout >300 mm was 467 mm and the size range was 311 to 620 mm (Figure 5). Seven fish smaller than 300 mm were captured (size ranged from 145 to 198 mm). These fish were age 1 (stocked in 1999) and were not used in further analysis. During Event 2 (21 - 25 August), 43 rainbow trout larger than 300 mm were captured of which 15 were recaptured from Event 1. The average size of rainbow trout captured in August was 493 mm and the size range was 420 to 621 mm (Figure 5). None of the rainbow trout captured in August were from the age-1 cohort stocked in 1999.

Plots of the cumulative distribution functions (cdfs) showed fish captured in Event 1 were generally smaller than fish captured in Event 2 (Figure 6). The shapes of the cdfs for fish captured in Event 1 and Event 2 were similar but the cdf for Event 2 was shifted to the right. The cdfs for unmarked fish and fish recaptured in Event 2 were also shifted to the right. Results of K-S tests indicated that the cdfs were significantly different ($p<0.001$ for Event 1 vs Event 2 and $p=0.028$ for Event 1 vs recaptured fish); however, this difference is likely due to a shift in central tendency as a result of growth occurring between Events 1 and 2.

Because the K-S test is sensitive to growth during the experiment we also conducted Chi-squared (contingency table) tests on the data. Although not as precise as using K-S tests this method is more appropriate in this situation because it is less sensitive to the problem of growth occurring between sampling events. This is a valid method because there are only a few age classes in the population and all are available to the capture gear. Length data were partitioned at the mean into large and small fish for each event (467 mm for Event 1 and 493 mm for Event 2). We infer from the results of these tests that there was no size bias during the experiment ($p = 0.64$ for recaptured vs. not recaptured fish and $p = 0.77$ for marked vs. unmarked fish). Data were not stratified to estimate abundance.

The estimated abundance of rainbow trout was 472 (SE = 87). Since few small fish were captured, the proportions for fish <355 mm, 355 to 460 mm, and >460 mm were not calculated. Instead, proportions were calculated for fish 350 to <480 mm, 480 to 520 mm, and >520 mm (Table 2). Due to growth between capture events and the small sample size during Event 2, only fish from Event 1 were used to estimate proportions.

In June, 144 landlocked coho salmon were captured during Event 1. During Event 2, in August, 217 coho salmon were captured of which 30 were marked (recaptured). None of the captured coho salmon was smaller than 200 mm in June. In August, 117 age-0 coho salmon less than

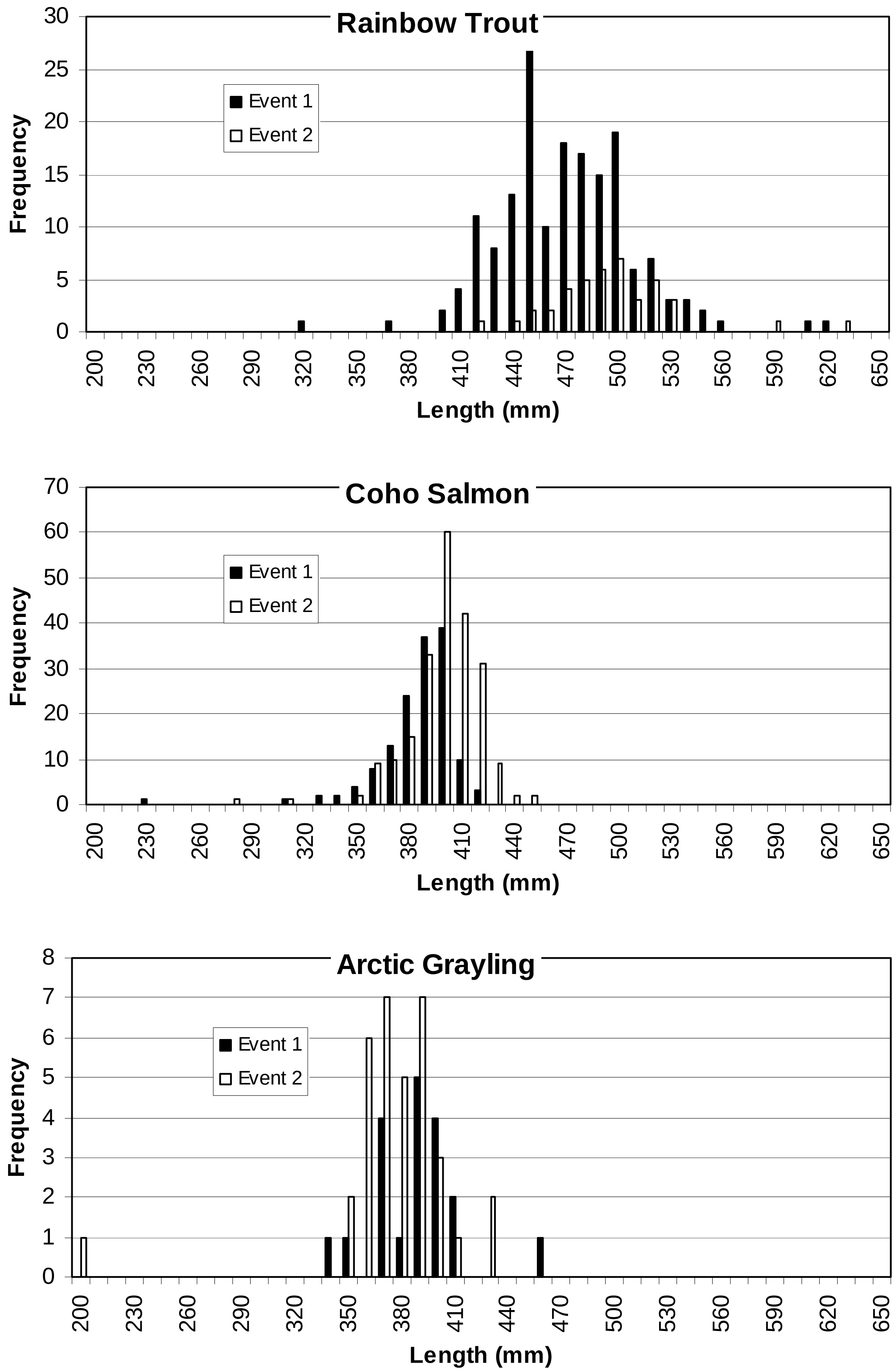

Figure 5.-Length frequency histograms of fish captured during the mark-recapture experiment at Dune Lake.

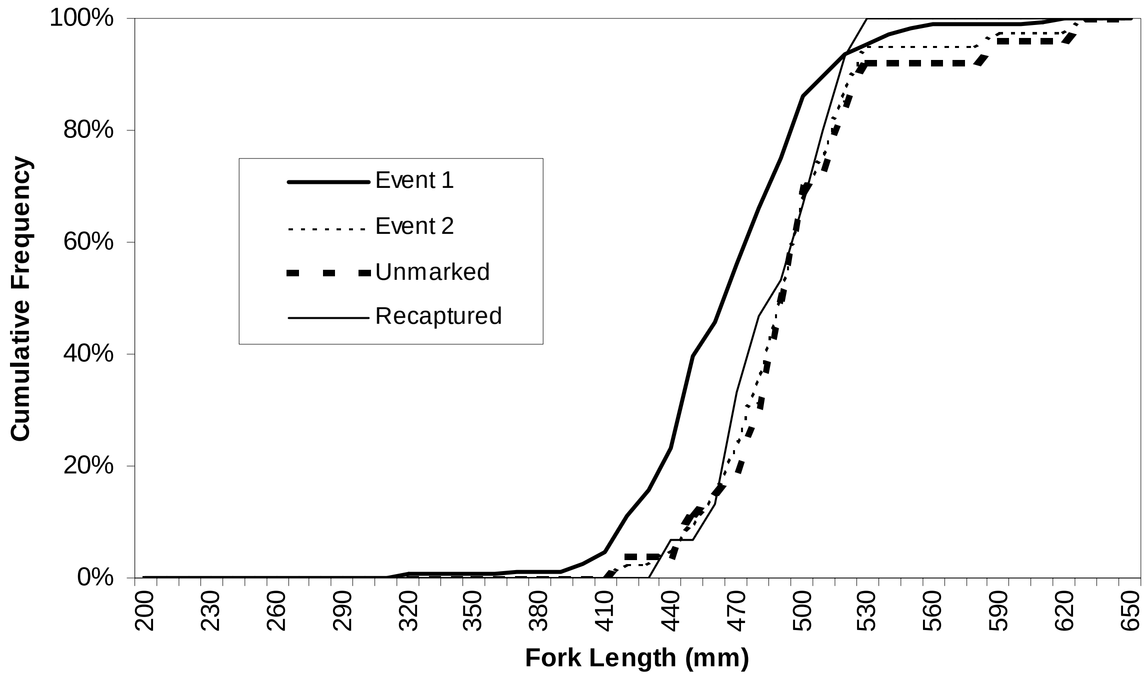

Figure 6.–Cumulative distribution function of lengths from rainbow trout captured during the mark-recapture experiment at Dune Lake.

Table 2.-Length composition of the rainbow trout population using data from fish captured during Event 1.

Length Category	Small 350 to <480 mm	Medium 480 to 520 mm	Large >520 mm	Total
Sample Size	107	53	11	171
Proportion	0.63	0.31	0.06	1
SE	0.04	0.04	0.02	
Abundance	295	146	30	472
SE	57	32	10	

200 mm were captured. These fish were stocked 27 June 2000 and were not used in further analysis. The average size of coho salmon caught in August was 395 mm (Figure 5). The size ranged from 273 to 445 mm. CDFs for Event 1 vs Event 2 and Event 1 vs recaptured fish were significantly different (Figure 6; $p<0.001$ for both K-S tests). However, size selectivity was not a concern in the mark-recapture experiment because the difference between distributions was likely due to growth between sampling events. The cdfs had similar shapes but the central tendencies were different (Figure 7); therefore, data were not stratified to estimate abundance.

The estimated abundance of coho salmon was 1,028 (SE = 150). During Event 1, the proportion of coho salmon <400 mm was 0.86 (SE = 0.03), while the proportion ≥400 mm was 0.14 (SE = 0.03, Table 3). However, during the hiatus between capture events the size of coho salmon increased sufficiently so about one-half of the catch was larger than 400 mm. During Event 2, the proportion of coho salmon <400 mm was 0.52 (SE = 0.03), while the proportion ≥400 mm was 0.48 (SE = 0.03, Table 4).

All rainbow trout from which scale samples were collected were age-3. These fish were on their fourth summer. Coho salmon were age-2 and on their third summer.

Only 28 Arctic grayling were captured during the study and no marked Arctic grayling were recaptured. The average size of Arctic grayling in August was 376 mm and ranged from 343 to 426 mm (Figure 5). One 125 mm Arctic grayling was excluded from the analysis. No abundance estimate was made for Arctic grayling.

During this experiment there was no immigration, emigration, or recruitment because the lake was closed (no inlet or outlet) and there was no natural reproduction. We found 1 marked and 2 unmarked dead rainbow trout during Event 1. We suspect these fish died during spawning because their bodies were extremely thin and covered with lesions. Natural mortality would have no effect on the estimate if marked and unmarked fish had the same rate of mortality. If natural mortality occurred, then the estimate would be germane to Event 1. Angling occurred during the experiment but we don't know how many fish were harvested or the marked to unmarked ratio of the harvested fish. If fishing mortality was the same for both marked and unmarked fish then the abundance estimate was germane to Event 1.

Catches of fish and observations made during this experiment indicate that the abundance of age-1 rainbow trout in Dune Lake was lower than expected based on the number of fish that were stocked in 1999 (Appendix A1). This suggests that there was a problem with survival of stocked fingerlings and future recruitment to the fishery will be very low. During the mark-recapture experiment only 7 age-1 rainbow trout were captured that were stocked as fingerlings in 1999. Usually, during this type of experiment, most of the catch is made up of smaller, younger fish. The age-1 cohort of rainbow trout, however, is missing. If age-1 rainbow trout were present they should have been captured because coho salmon smaller and larger than that expected for age-1 rainbow trout were captured. In other lakes (Birch and Quartz lakes) all age cohorts of rainbow trout and coho salmon were commonly captured together in fyke nets. The crew conducting the study at Dune Lake also observed age-0 and age-2 coho salmon near shore along with age-3 rainbow trout but the crew did not see any age-1 rainbow trout.

Possible explanations for the absence of age-1 rainbow trout are that there was predation by coho salmon and older rainbow trout or the fish were injured during transport by aircraft to the lake. The pilot who transported the rainbow trout to Dune Lake noted that the fish did not display any physical signs of stress or injury. He also transported rainbow trout to three other lakes in the

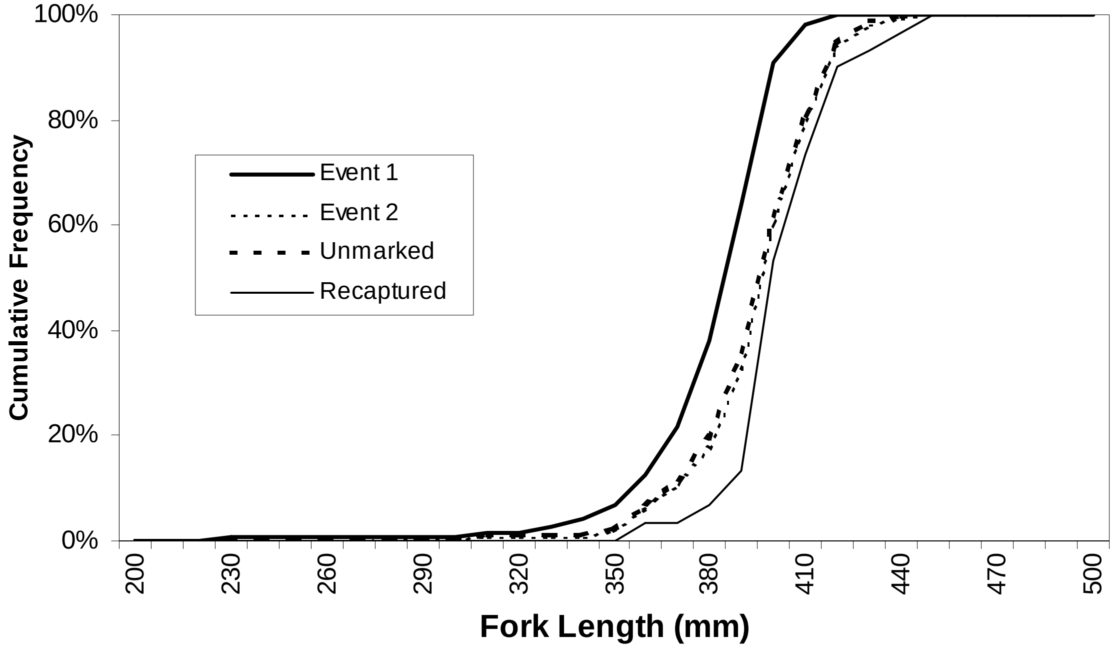

Figure 7.–Cumulative distribution function of lengths from coho salmon captured during the mark-recapture experiment at Dune Lake.

Table 3.-Length composition of the coho salmon population using data from fish captured during Event 1.

Length Category	Small <400	Large ≥400	Total
Sample Size	124	20	144
Proportion	0.86	0.14	1
SE	0.03	0.03	
Abundance	885	143	1,028
SE	132	36	

Table 4.-Length composition of the coho salmon population using data from fish captured during Event 2.

Length Category	Small <400	Large ≥400	Total
Sample Size	112	105	217
Proportion	0.52	0.48	1
SE	0.03	0.03	
Abundance	531	497	1,028
SE	85	80	

same general area the same day. Rainbow trout at one of these lakes, Tschute Lake, were sampled using fyke nets in spring 2000. The number of fish captured (53) and their average size at age-1 (180 mm) were what we would expect. No wild or stocked fish were present in Tschute Lake when it was first stocked in 1999.

The recent decline in the number of large rainbow trout observed by anglers may be exacerbated by the large increase in the number of rainbow trout harvested. From 1990 to 1998, the number of rainbow trout harvested from Dune Lake ranged from 166 to 959 fish. The number of rainbow trout harvested in 1999 was 2,006. However, neither the number of anglers nor the amount of effort have increased significantly since 1990. Anglers kept a larger portion of their catch in 1999 compared to previous years.

RECOMMENDATION

The goal of these recommendations is to improve the quality of the rainbow trout fishery at Dune Lake by increasing the abundance of large rainbow trout. Although large rainbow trout are present, anglers have noticed recently that there are fewer large fish. The available data suggests that this is likely due to low survival rates for stocked fingerling rainbow trout, increased harvest of rainbow trout, or a combination of both.

If coho salmon is the main predator on fingerling rainbow trout in Dune Lake then a possible solution to increase the survival of fingerling rainbow trout is to reduce the number of coho salmon in the lake. This can be accomplished by eliminating or reducing the number of coho salmon that are stocked into the lake. However, if large rainbow trout are also a major predator on stocked rainbow trout fingerling, then eliminating or reducing the number of coho salmon may not have the desired result of reducing predation.

The current harvest level of 2,000 rainbow trout probably exceeds the capacity of the stocked population to maintain an adequate number of large rainbow trout. From 1990 to 1998, an annual harvest less than 1,000 rainbow trout maintained an acceptable fishery. With the current number of anglers and level of effort, reducing the daily bag and possession limit from 10 to 5 rainbow trout should reduce the annual harvest from 2,000 to 1,000 rainbow trout. However, if the number of anglers increases due to the popularity of this fishery, then the number of rainbow trout harvested annually may still exceed 1,000 rainbow trout.

ABUNDANCE AND COMPOSITION OF RAINBOW TROUT IN BLUFF CABIN, DONNA, AND LITTLE DONNA LAKES

In 1994 ADF&G initiated a program to create fisheries for large or trophy-size rainbow trout in Little Harding Lake (22 ha), Craig Lake (7 ha), and Coal Mine #5 Lake (5 ha; Figures 8 and 9). Special regulations were adopted for these lakes to increase the likelihood of creating successful fisheries. The criteria for success in establishing trophy fisheries for rainbow trout in these lakes is based on size composition and relative abundance. For these fisheries to be considered successful trophy fisheries, at least half of each age cohort must exceed 350 mm (14 in.) by age-4. When stocked, these fish were age-1 and average 150 to 180 mm. To date, only Little Harding Lake is approaching the criteria for a successful fishery. Craig Lake and Coal Mine #5

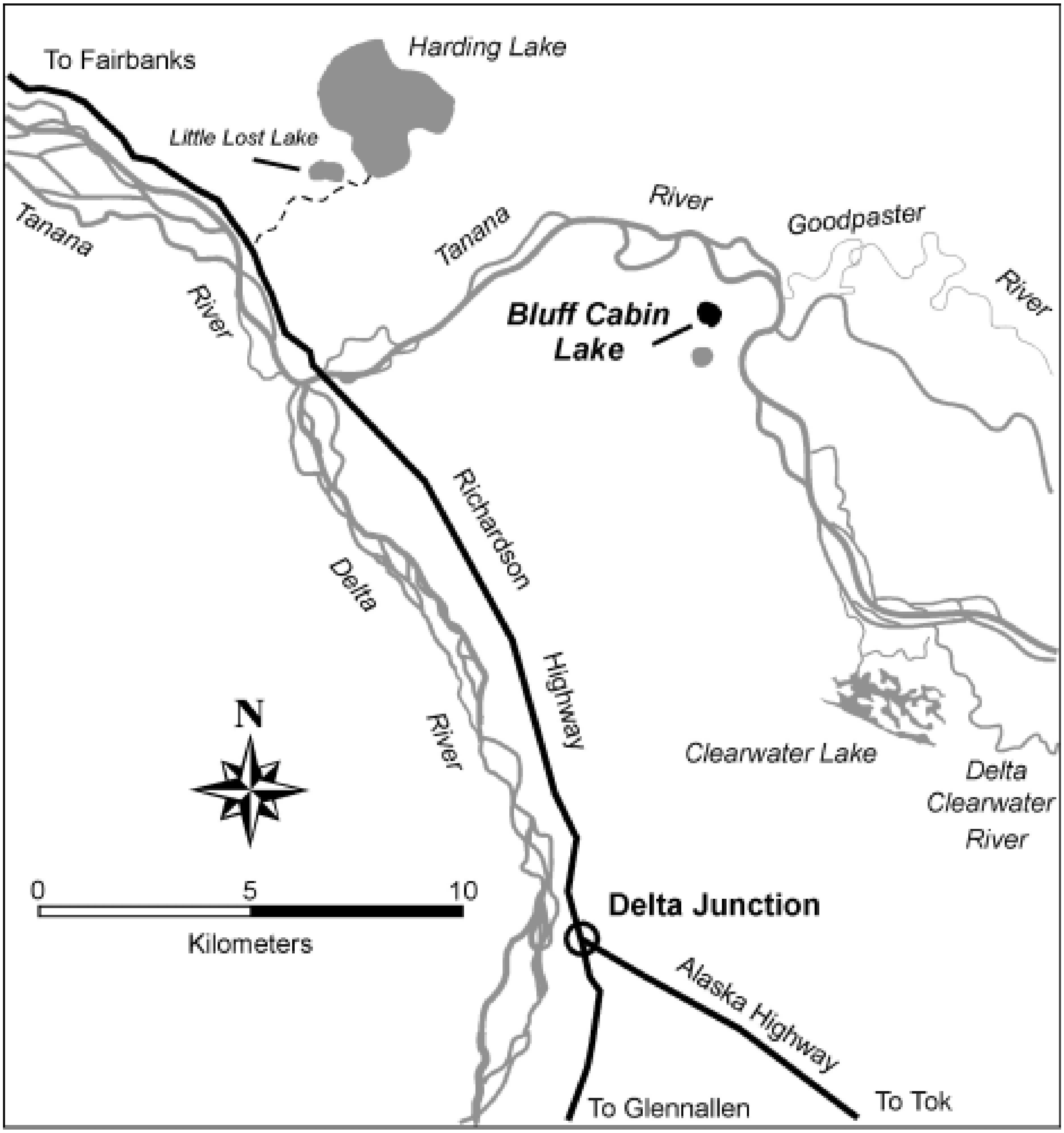

Figure 8.-Location of Bluff Cabin Lake in the Tanana Valley.

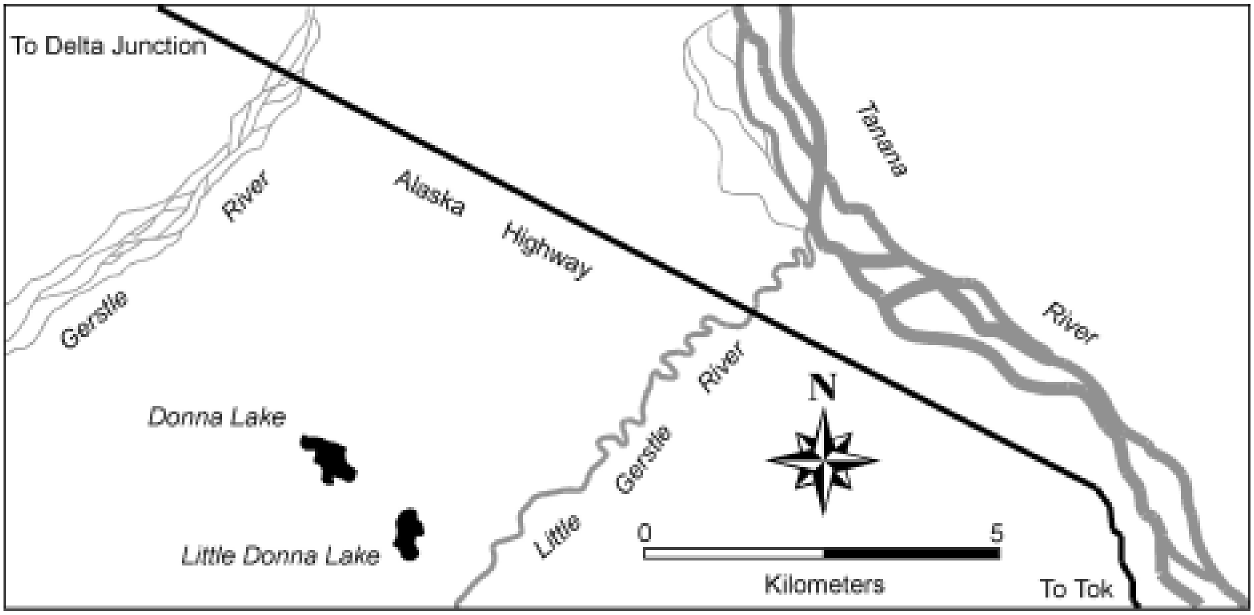

Figure 9.-Locations of Donna, and Little Donna Lakes in the Tanana Valley.

Lake have been dropped from future evaluation work because the criteria has not been met and it is unlikely that it will be met (Skaugstad 1999).

Additional lakes, which include Bluff Cabin Lake (29 ha) in Delta Junction, Donna Lake (24 ha), and Little Donna Lake (12 ha), along the Alaska Highway between Delta Junction and Tok, have been identified as candidate lakes to be managed for large rainbow trout. These lakes produce large fish and they may be capable of producing sufficient numbers of large rainbow trout to sustain a trophy fishery. The purpose of this study was to estimate the abundance and size structure of the rainbow trout populations in Bluff Cabin Lake, Donna Lake, and Little Donna Lake. This information along with limnological characteristics will be used to evaluate each lake's potential to produce large fish.

Specific objectives were as follows:

Management Objective: Determine the abundance of rainbow trout by size categories in Bluff Cabin Lake, Little Donna Lake, and Donna Lake.

Estimate proportions of rainbow trout for size categories (<355 mm, 355 to 460 mm, and >460 mm) in Bluff Cabin Lake, Little Donna Lake, and Donna Lake. These size categories correspond to <14", 14"–18", and >18".

Research Objective 1: Estimate the abundance of rainbow trout in Bluff Cabin Lake, Little Donna Lake, and Donna Lake such that $\Pr\left(\left|\frac{\hat{N}-N}{N}\right| \geq 0.25\right) = 0.05$.

Research Objective 2: Estimate the size composition of rainbow trout in Bluff Cabin Lake, Little Donna Lake, and Donna Lake such that $\Pr(|\hat{P} - P| \geq 0.05) = 0.05$.

Where P is the proportion of the population comprised of fish by size category. Size categories are: 250 to <355 mm, 355 to 460 mm, and >460 mm

METHODS

To estimate the abundance of rainbow trout we conducted a two-sample mark-recapture experiment in each lake. The equipment and methods were similar to those described for Dune Lake.

For Bluff Cabin Lake, the marking event (Event 1) occurred 6 and 7 June and the recapture event (Event 2) occurred 20 and 21 June. There was a hiatus of 12 days between events. Four fyke nets and two tangle nets were used during Event 1 and again during Event 2. During Event 1, fish captured in fyke nets were marked with a left ventral fin clip. All fish captured in Event 2 were marked with an upper caudal fin clip regardless of capture gear. Any fish captured in Event 2 without a left ventral fin clip was classified as unmarked (captured for the first time). Any fish captured more than once during either event was counted only once per event. We measured all captured fish to the nearest millimeter fork length (FL).

For Donna Lake, Event 1 occurred 16 and 17 August and Event 2 occurred 30 August and 1 September. There was a hiatus of 12 days between events. For Little Donna Lake, Event 1 occurred 8-10 August and Event 2 occurred 31 August and 1 September. There was a hiatus of 20 days between events. Three fyke nets and one tangle net were used at each lake. For both lakes, fish captured in fyke nets during Event 1 were marked with an upper caudal fin clip, those captured in tangle nets were marked with a left ventral fin clip, and fish captured with sport-fishing gear were marked with an adipose fin clip. Fish captured during Event 2 were marked with a lower caudal fin clip regardless of capture gear.

To test for size bias during the experiment we used either Kolmogorov-Smirnov (K-S) tests, contingency tables, or both (Appendix B). K-S tests usually were used when the length distribution of captured fish had one mode and there was no evidence of growth during the experiment. Contingency tables were used when length distributions were bimodal or when there was growth during the experiment and the length distributions were either single or bimodal. To conduct these tests we first separated captured fish into age/size groups using length frequency distributions of fish captured only once in both events. Generally, these distributions have two modes that represent small (usually age-1) and large fish (usually age-3 and older) or a single mode representing age-3 and older fish. Bimodal length distributions were divided between the modes at the category that had the lowest count. We then evaluated size bias using contingency tables. Although this method is not as precise as using K-S tests, it is preferred because it is less sensitive to the problem caused when growth occurs between sampling events. It also provides an appropriate rational for stratifying the population by size if we observe that capture probabilities are different for smaller and larger fish. Contingency tables also were used for single mode length distributions when growth was evident. Length frequency distributions were divided at the mode into small fish and large fish for each capture event. If the mode could not be determined by visual inspection of the length frequency distribution then the mean was calculated and used to divide the sample. K-S tests were used to test for bias when length frequency distributions had a single mode and there was little or no growth, or when there was no clear separation between age/size categories. Depending on the outcome of these tests, we made appropriate adjustments as outlined in Appendix C. Equations 1 and 2 were used to estimate abundance.

RESULTS AND DISCUSSION

Bluff Cabin Lake

We captured and marked 585 rainbow trout during Event 1. During Event 2 we captured 514 fish, 65 of which were recaptured. A total of 1,034 unique fish were handled during the experiment. No fish were captured in tangle nets during Event 1 and only 6 fish were captured in tangle nets during Event 2. Of those 6, one had originally been captured in a fyke net during Event 1. Fish <200 mm were not marked during Event 1 because they were age 1 and we were interested in the abundance of older fish. Consequently, data analysis and abundance estimates for Bluff Cabin Lake were restricted to fish ≥250 mm. Because Bluff Cabin Lake is stocked every other year, there were no fish between 200 and 250 mm. After restricting the data, 447 fish were captured in Event 1 and 129 were captured in Event 2 of which 63 were recaptured (Table 5 and Figures 10 and 11). The length frequency distribution had a single mode and there appeared to be little growth during the experiment which allowed the use of K-S tests to evaluate size bias. Results of the K-S tests indicated there was size bias during Event 1 but no size bias during Event 2 ($p = 0.07$ for Event 1 vs. Event 2 and $p = 0.66$ for fish captured in Event 1 vs. those recaptured in Event 2). This allows the use of an unstratified estimate of abundance. We also conducted Chi-squared (contingency table) tests on the data to determine if growth had

Table 5.-Summary of capture histories and estimates of abundance of rainbow trout caught during mark-recapture experiments in Bluff Cabin, Donna, and Little Donna lakes.

	Number Marked	Number Examined	Number Recaptured	$\hat{N}$	SE ($\hat{N}$)
Bluff Cabin Lake	447	129	63	909	74
Donna Lake	325	253	39	2,069	278
Little Donna Lake	176	83	8	1,651	481

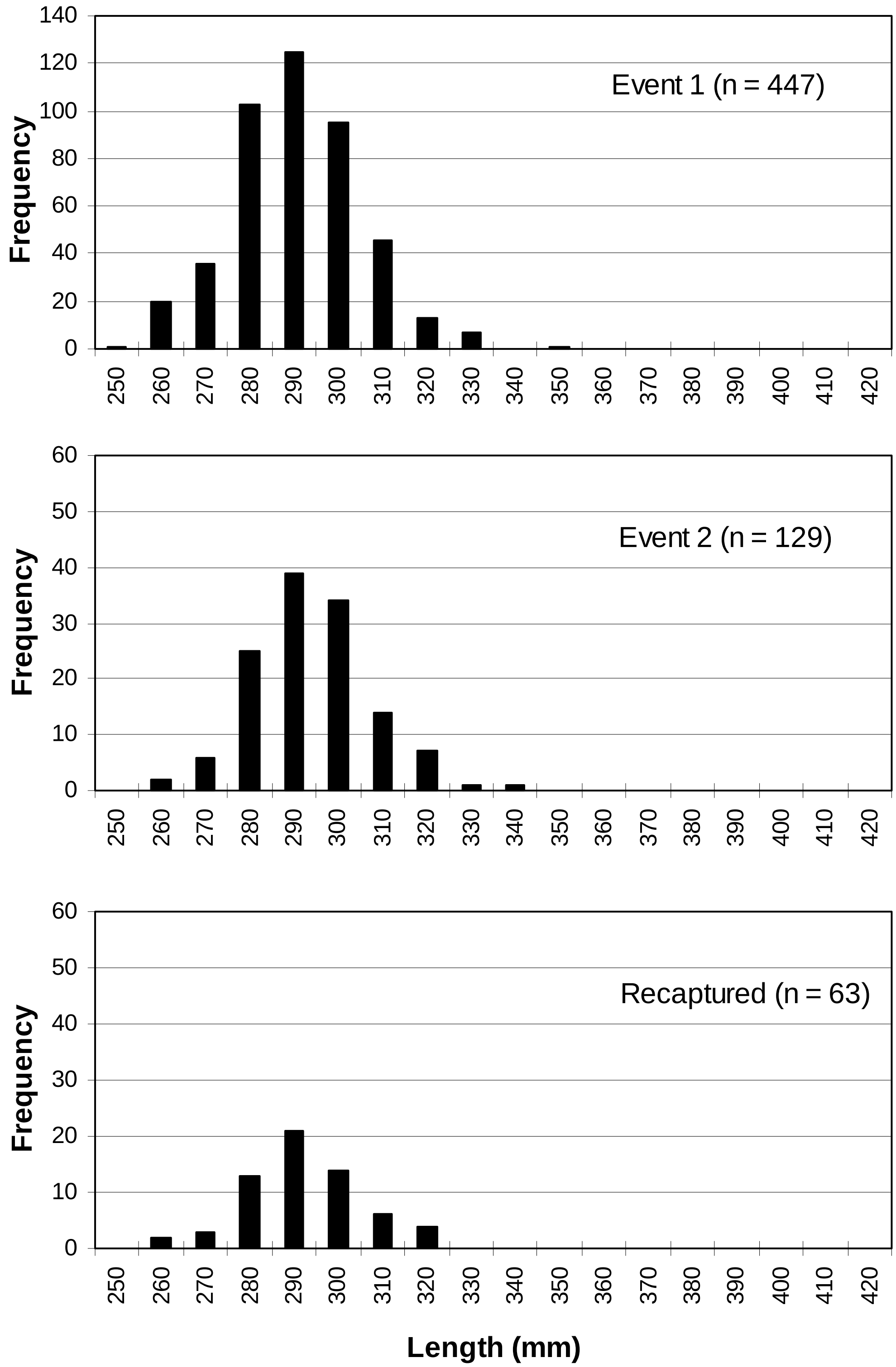

Figure 10.-Length frequency distribution of rainbow trout captured by sampling event at Bluff Cabin Lake.

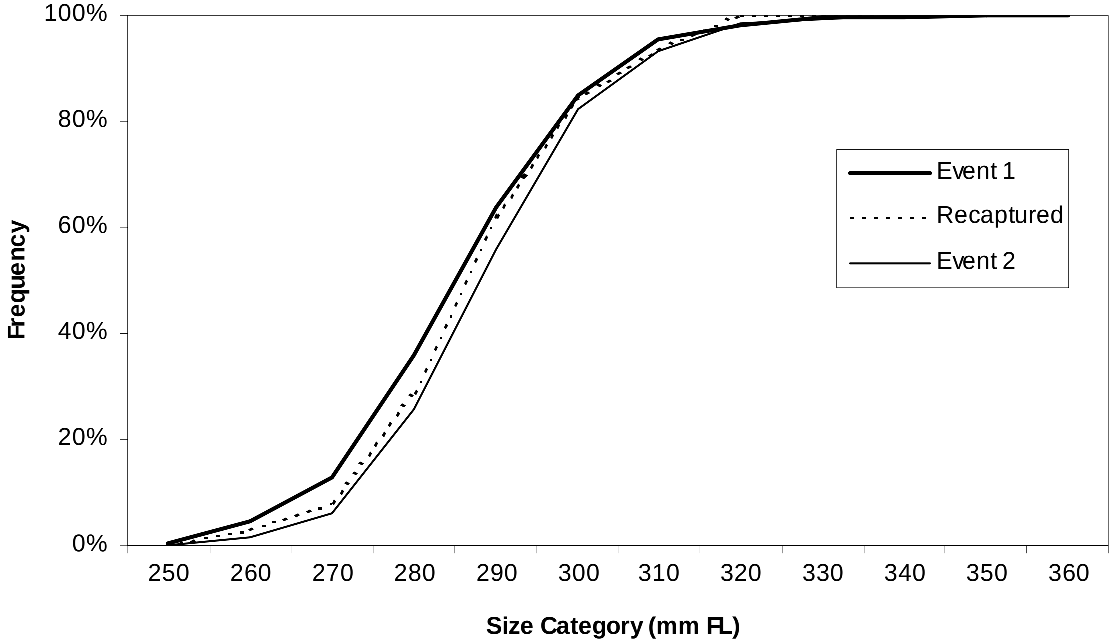

Figure 11.-Cumulative length frequency distribution of rainbow trout captured in Event 1, Event 2, or captured in both events (recaptured), Bluff Cabin Lake.

some effect on the outcome of the K-S test. Length data were partitioned at 290 mm for both events. We infer from the results of these tests that size bias during Event 1 was a result of growth ($p = 0.49$ for recaptured vs. not recaptured and $p = 0.33$ for marked vs. unmarked fish). During late August to late September, Doxey (1989) observed that rainbow trout grow approximately 1 mm per day on average. The unstratified estimated abundance of rainbow trout was 909 (SE = 74, Table 6). Because the largest fish captured in Bluff Cabin Lake was <350 mm we did not apportion the estimate by size category.

Even though there was growth between events, no new fish entered the population during the experiment. This allowed us to ignore growth as a factor that would bias the estimate of abundance. Also, during this experiment there was no immigration or emigration because the lake was closed (no inlet or outlet) and there was no natural reproduction. There may have been mortality during the experiment, which makes the estimate germane to the time of the first event but not the second event. This, however, was probably minimal because we saw no anglers during the experiment and there was no evidence of fishing activity during the hiatus. Most fishing at Bluff Cabin Lake occurs during winter.

Donna Lake

Three hundred twenty five fish were marked during Event 1 and 253 fish were captured during Event 2 of which 39 were recaptured from Event 1 (Table 5; Figures 12 and 13). During the experiment 539 unique fish were captured. During Event 1, 13 fish were captured by tangle net and 33 fish were captured by sport-fishing gear. The rest of the fish were captured by fyke net. During Event 2, three fish were captured by tangle net, 10 fish were captured by sport-fishing gear (none of these fish had been captured during Event 1), and the remaining fish were captured by fyke net. Of 39 fish recaptured during Event 2, only 2 were originally caught by tangle net and the rest were originally captured by fyke net.

The length frequency distribution of unique fish captured during the experiment was bimodal and was composed of smaller age-1 fish and larger age-3 and older fish. Age-1 fish were included in the analysis. The two modes were divided at 290 mm for analysis. Chi-squared tests did not suggest size bias between events ($\chi2 = 0.12$; 1 df; $P = 0.73$ for recaptured vs. not recaptured; and $\chi2 = 0.19$; 1 df; $P = 0.66$ for marked vs. unmarked fish). An unstratified estimate of total abundance was 2,069 (SE = 278). The abundance of fish by size category are listed in Table 6. The largest fish captured in Donna Lake was 401 mm.

Little Donna Lake

In Little Donna Lake, 176 fish were captured and marked during Event 1. Eighty-three fish were captured during Event 2 of which 8 were recaptured from Event 1 (Table 5; Figures 14 and 15). During the experiment 251 unique fish were captured. Thirty six fish were captured by tangle net and 3 fish were captured by sport-fishing gear during Event 1. During the second event, 15 fish were captured by tangle net and 11 fish were captured by sport-fishing gear (one of which was captured twice during Event 2). Of 8 fish recaptured during the second event, only 1 was originally caught by sport-fishing gear, the rest were originally captured by fyke nets.

The length frequency distribution of unique fish captured during the experiment show two and possibly a third size/age category (ages 1, 3 and possibly 5). The length data were divided at 300 mm for analysis. Chi-squared tests did not suggest size bias between events ($p = 0.52$ for recaptured vs. not recaptured; and ($p = 0.42$ for marked vs. unmarked fish). An unstratified

Table 6.-Estimates of proportions and abundances by length category in Bluff Cabin, Donna, and Little Donna Lakes.

Length	n	p	SE(p)	CV(p)%	$\hat{N}$	SE($\hat{N}$)	CV($\hat{N}$)%
Bluff Cabin Lake							
>250 mm FL					897	72	12.6
Donna Lake							
<355 mm FL	499	0.93	0.01	1.2	1,916	258	13.5
≥355 mm FL	40	0.07	0.01	15.2	154	31	20.2
≥460 mm FL	0				0		
Total					2,060		
Little Donna Lake							
<355 mm FL	221	0.88	0.02	2.3	1,454	425	29.2
≥355 to <450 FL	28	0.11	0.02	17.8	184	62	33.7
≥460 mm FL	2	0.01	0.006	70.4	13	10	73.4
Total					1,651		

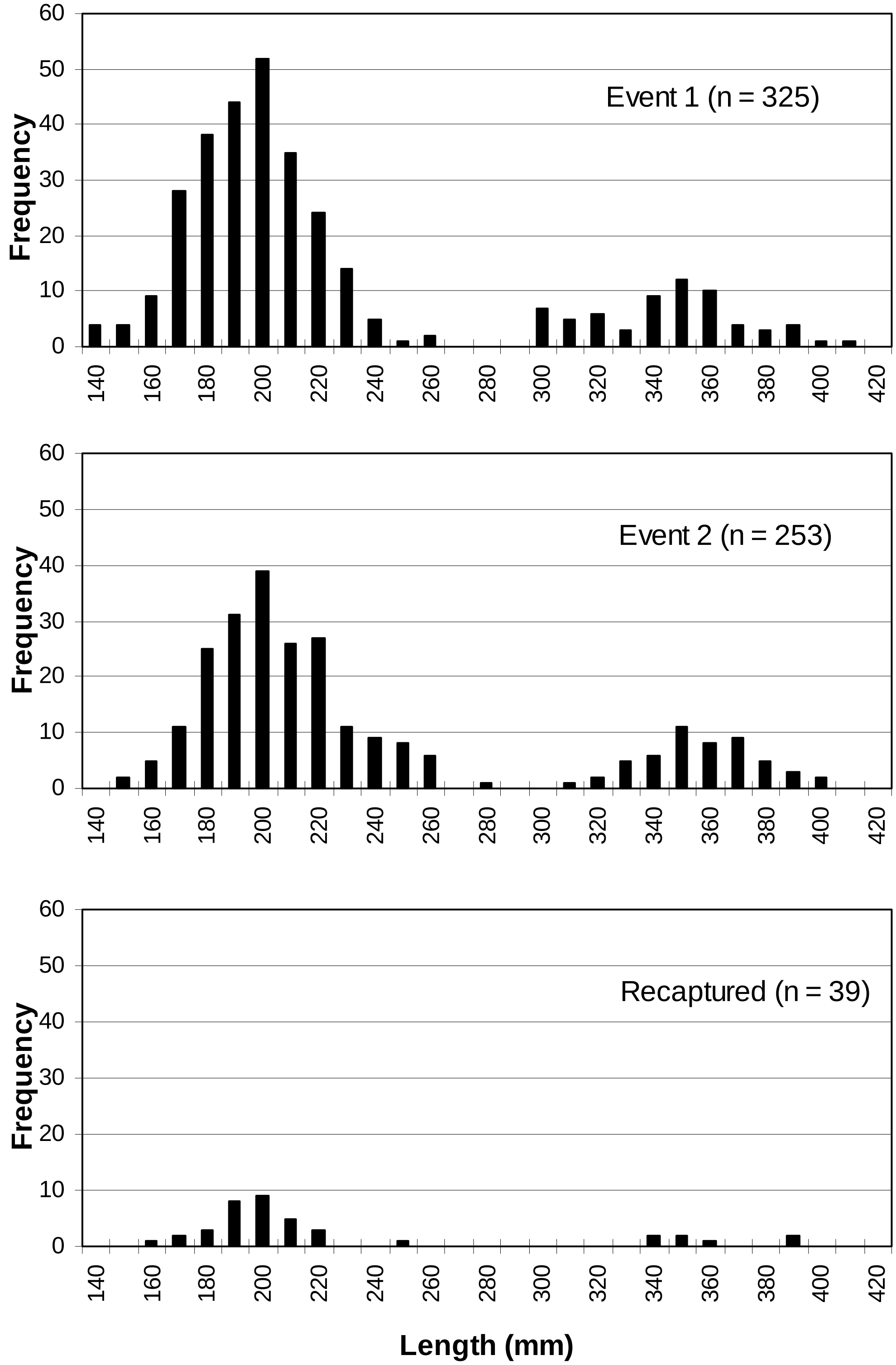

Figure 12.-Length frequency distribution of rainbow trout captured by sampling event at Donna Lake.

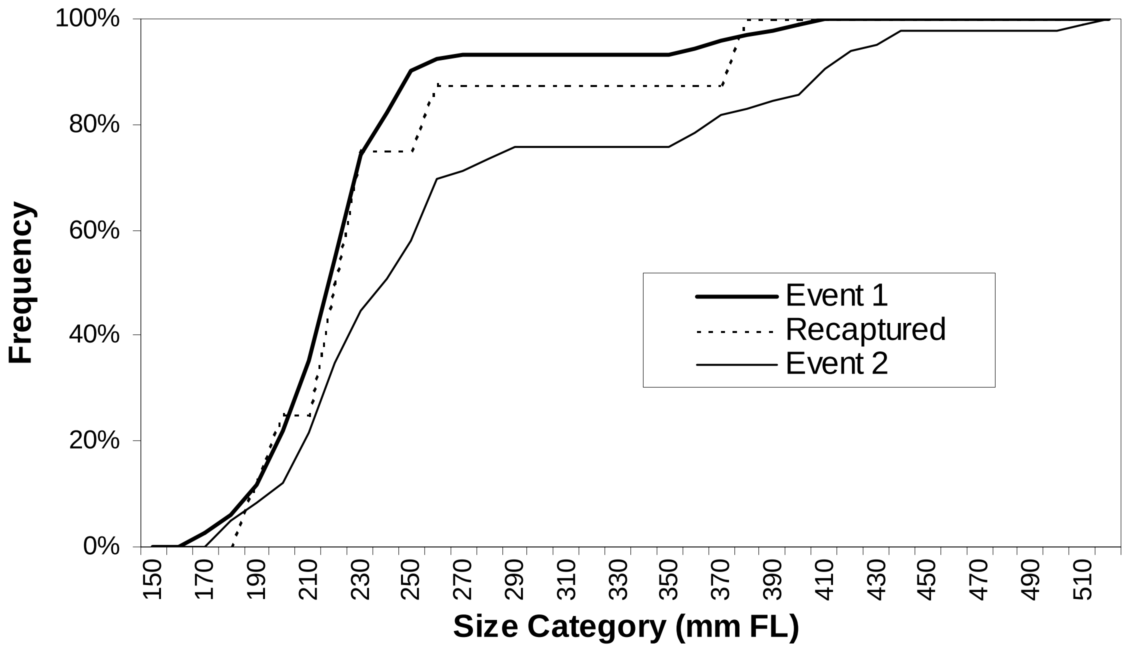

Figure 13.-Cumulative length frequency distribution of rainbow trout captured in Event 1, Event 2 or captured in both events (recaptured), Donna Lake.

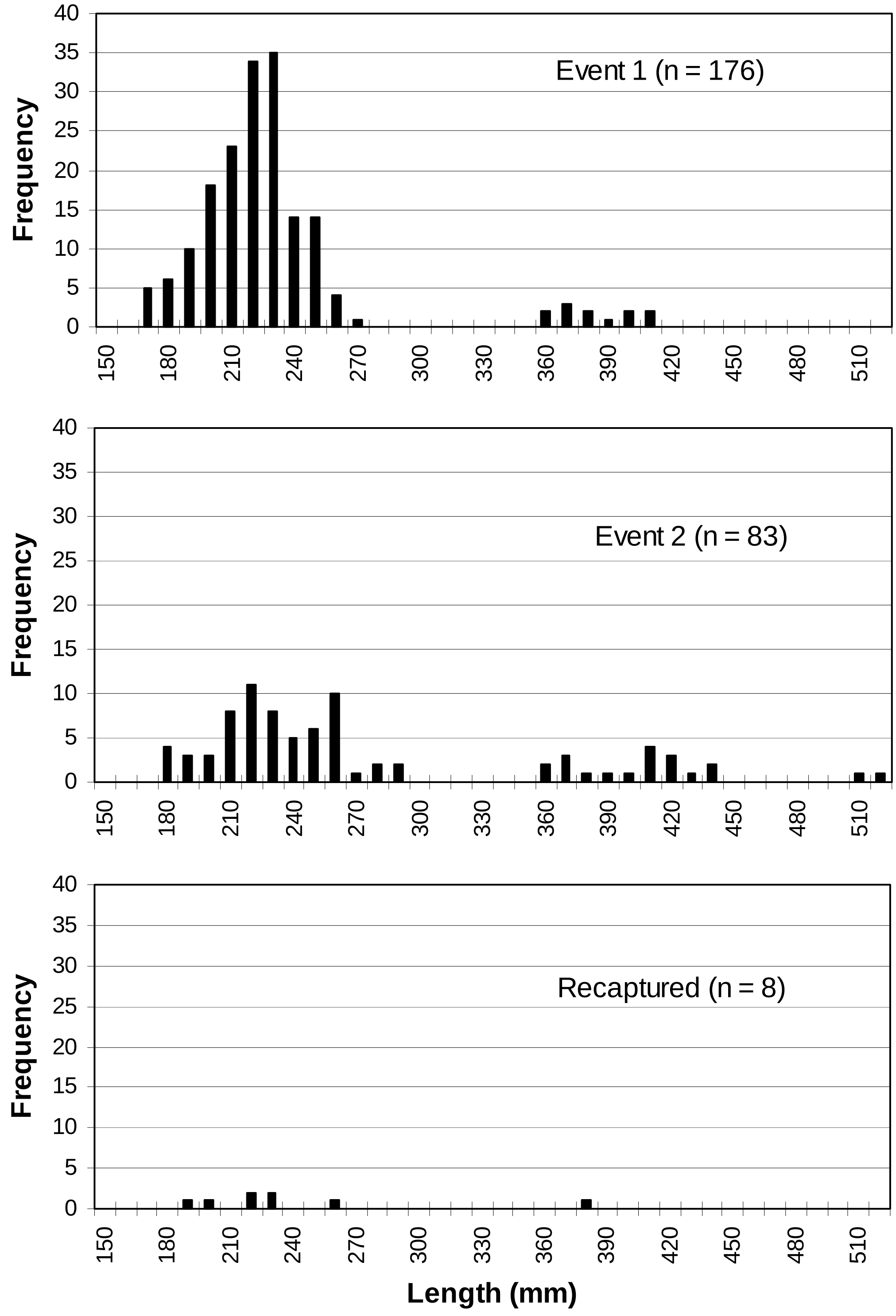

Figure 14.-Length frequency distribution of rainbow trout captured by sampling event at Little Donna Lake.

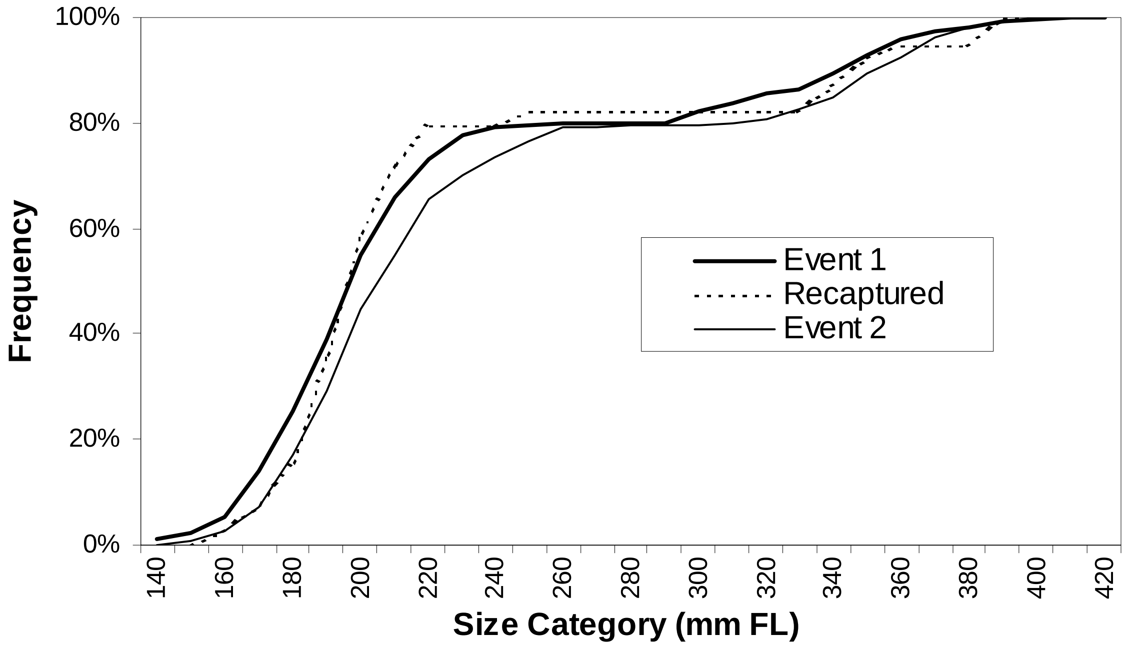

Figure 15.-Cumulative length frequency distribution of rainbow trout captured in Event 1, Event 2, or captured in both events (recaptured), Little Donna Lake.

estimate of total abundance was 1,651 (SE = 481). The abundance of fish by size category are listed in Table 6. The largest fish captured in Little Donna Lake was 520 mm.

During these experiments there was no immigration or emigration because Donna and Little Donna lakes were closed (no inlet or outlet) and there was no natural reproduction. Natural mortality likely occurred, but it would have no effect on the estimate if marked and unmarked fish had the same rate of mortality. The estimate, however, would be germane to Event 1. We assume fishing mortality was low because we saw no anglers during the experiment and there was no evidence of fishing activity during the hiatus. Most fishing at these two lakes occurs during winter.

Fisheries for Large Rainbow Trout

Both Donna and Little Donna lakes have produced rainbow trout larger than 400 mm. If current stocking practice and fishing regulations were modified, a trophy fishery may be established. To produce a greater abundance of large fish we would reduce the number of fish stocked each year to promote growth, reduce the bag limit, and place size restrictions on the harvest to maintain sufficient numbers of large fish. However, at this time there is no public support to change either stocking practices or regulations. Local public support is for consumptive fisheries and local anglers think that these two lakes provide sufficient numbers of large fish without having to reduce stocking levels or bag limits. Under current stocking and management practices, Bluff Cabin Lake has not produced large fish that would support a viable trophy rainbow trout fishery.

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APPENDIX A
STOCKING HISTORY

Appendix A1.-Stocking history for Dune Lake, 1976-2000.

Species	Stocking Date	Number Stocked	Age[a]	Sex[b]	Weight (g)	Brood Year
Arctic Grayling	28-Jun-76	75,000	E	MF	0.02	76
Arctic Grayling	11-Jun-81	50,394	E	MF	0.02	81
Arctic Grayling	3-Jun-83	50,000	E	MF	0.02	83
Arctic Grayling	14-Jun-84	50,000	E	MF	0.01	84
Arctic Grayling	27-Aug-87	5,000	F	MF	4.7	87
Arctic Grayling	23-Aug-88	5,000	F	MF	2.4	88
Arctic Grayling	31-Aug-89	5,000	F	MF	2.5	89
Arctic Grayling	31-Aug-92	18,000	F	MF	2.4	92
Arctic Grayling	29-Aug-94	18,000	F	MF	3.5	94
Arctic Grayling	20-Aug-96	18,000	F	MF	1.3	96
Arctic Grayling	29-Aug-00	10,794	F	MF	1.3	00
Coho Salmon	30-Apr-87	20,000	F	MF	2.0	86
Coho Salmon	1-Jun-89	10,000	F	MF	4.1	88
Coho Salmon	3-Jun-93	3,000	S	MF	11.1	91
Coho Salmon	1-Jun-94	18,000	F	MF	3.2	93
Coho Salmon	18-Jun-96	18,000	F	MF	5.0	95
Coho Salmon	24-Jun-98	11,003	F	MF	2.8	97
Coho Salmon	27-Jun-00	8,836	F	MF	4.7	99
Rainbow Trout	21-Aug-84	2,500	F	MF	2.2	84
Rainbow Trout	27-Aug-87	10,000	F	MF	2.2	87
Rainbow Trout	23-Aug-88	10,000	F	MF	1.3	88
Rainbow Trout	9-Aug-89	10,000	F	MF	1.0	89
Rainbow Trout	25-Jul-91	10,000	F	MF	1.6	91
Rainbow Trout	3-Aug-93	18,000	F	MF	1.2	93
Rainbow Trout	17-Jul-95	2,500	F	MF	1.1	95
Rainbow Trout	17-Jul-95	15,500	F	MF	1.2	95
Rainbow Trout	27-Aug-97	10,000	F	MF	2.6	97
Rainbow Trout	22-Jul-99	10,000	F	MF	1.4	99
Rainbow Trout	29-Aug-00	5,009	F	MF	3.8	00

[a] E = eyed eggs, F = fingerling, S = subcatchable.

[b] MF = male and female diploid.

Appendix A2.-Stocking history for Bluff Cabin Lake, 1980-1999.

Species	Stocking Date	Number Stocked	Age[a]	Sex[b]	Weight (g)	Brood Year
Rainbow Trout	23-Jul-80	4,995	F	MF	1.1	80
Rainbow Trout	14-Sep-83	10,000	F	MF	1.6	83
Rainbow Trout	26-Aug-85	10,000	F	MF	1.6	85
Rainbow Trout	26-Aug-87	10,000	F	MF	2.0	87
Rainbow Trout	10-Aug-89	14,000	F	MF	1.0	89
Rainbow Trout	6-Aug-91	14,400	F	MF	2.0	91
Rainbow Trout	20-Jul-93	14,500	F	MF	1.6	93
Rainbow Trout	27-Jul-95	14,376	F	MF	1.3	95
Rainbow Trout	13-Aug-97	7,000	F	MF	2.0	97
Rainbow Trout	26-Jul-99	6,905	F	MF	1.7	99

[a] F = fingerling.

[b] MF = male and female diploid.

Appendix A3.-Stocking history for Donna Lake, 1962-1999.

Species	Stocking Date	Number Stocked	Age[a]	Sex[b]	Weight (g)	Brood Year
Rainbow Trout	13-Sep-62	4,100	F	MF	3.6	62
Rainbow Trout	14-Aug-63	5,000	FR	MF	0.6	63
Rainbow Trout	13-Aug-64	7,410	F	MF	1.2	64
Rainbow Trout	4-Aug-65	7,950	F	MF	1.5	65
Rainbow Trout	2-Aug-66	10,000	F	MF	1.1	66
Rainbow Trout	19-Sep-68	9,800	F	MF	1.7	68
Rainbow Trout	31-Jul-69	10,000	F	MF	1.0	69
Rainbow Trout	24-Sep-70	6,300	F	MF	4.2	70
Rainbow Trout	22-Jun-71	50,000	F	MF	1.5	71
Rainbow Trout	12-Sep-72	8,700	F	MF	3.1	72
Rainbow Trout	18-Jul-73	29,000	F	MF	2.7	73
Rainbow Trout	23-Jul-74	22,900	F	MF	1.6	74
Rainbow Trout	24-Aug-76	23,100	F	MF	2.6	75
Rainbow Trout	23-Jul-80	4,995	F	MF	1.1	80
Rainbow Trout	14-Sep-83	15,900	F	MF	1.6	83
Rainbow Trout	26-Aug-85	11,600	F	MF	1.6	85
Rainbow Trout	26-Aug-87	11,600	F	MF	2.0	87
Rainbow Trout	10-Aug-89	15,000	F	MF	1.0	89
Rainbow Trout	6-Aug-91	11,600	F	MF	2.0	91
Rainbow Trout	20-Jul-93	11,750	F	MF	1.6	93
Rainbow Trout	27-Jul-95	11,533	F	MF	1.3	95
Rainbow Trout	13-Aug-97	11,600	F	MF	2.0	97
Rainbow Trout	26-Jul-99	11,488	F	MF	1.7	99

[a] F = fingerling; FR= fry.

[b] MF = male and female diploid.

Appendix A4.-Stocking history for Little Donna Lake, 1963-1999.

Species	Stocking Date	Number Stocked	Age[a]	Sex[b]	Weight (g)	Brood Year
Rainbow Trout	14-Aug-63	5,000	FR	MF	0.7	63
Rainbow Trout	13-Aug-64	3,990	F	MF	1.2	64
Rainbow Trout	3-Aug-65	5,950	F	MF	1.5	65
Rainbow Trout	2-Aug-66	2,000	F	MF	1.1	66
Rainbow Trout	19-Sep-68	9,900	F	MF	1.7	68
Rainbow Trout	31-Jul-69	5,000	F	MF	1.0	69
Rainbow Trout	24-Sep-70	3,700	F	MF	4.2	70
Rainbow Trout	22-Jun-71	15,000	F	MF	1.7	71
Rainbow Trout	12-Sep-72	6,200	F	MF	3.1	72
Rainbow Trout	18-Jul-73	13,300	F	MF	2.7	73
Rainbow Trout	23-Jul-74	16,300	F	MF	1.6	74
Rainbow Trout	18-Sep-79	3,550	F	MF	2.2	79
Rainbow Trout	14-Sep-83	12,500	F	MF	1.6	83
Rainbow Trout	26-Aug-85	9,400	F	MF	1.6	85
Rainbow Trout	26-Aug-87	9,400	F	MF	2.0	87
Rainbow Trout	10-Aug-89	6,000	F	MF	1.0	89
Rainbow Trout	6-Aug-91	9,400	F	MF	2.0	91
Rainbow Trout	20-Jul-93	6,063	F	MF	1.6	93
Rainbow Trout	27-Jul-95	5,977	F	MF	1.3	95
Rainbow Trout	13-Aug-97	6,000	F	MF	2.0	97
Rainbow Trout	26-Jul-99	6,000	F	MF	1.7	99

[a] F = fingerling; FR= fry.

[b] MF = male and female diploid.

APPENDIX B
ASSUMPTIONS NECESSARY FOR ACCURATE ESTIMATION OF ABUNDANCE IN A CLOSED POPULATION

Appendix B.-Assumptions necessary for accurate estimation of abundance in a closed population.

The assumptions necessary for accurate estimation of abundance in a closed population were as follows (taken from Seber 1982):

1. the population was closed (no change in the number of rainbow trout in the population during the estimation experiment; i.e. there was no immigration, emigration, births or deaths);

2. all rainbow trout have the same probability of capture in the marking sample or in the recapture sample, or marked and unmarked rainbow trout mix completely between marking and recapture events;

3. marking rainbow trout does not affect their probability of capture in the recapture sample;

4. rainbow trout do not lose their mark between the marking and recapture events; and,

5. all marked rainbow trout were reported when recovered in the recapture sample.

For assumption 1, no immigration or emigration was assured because the lakes do not have inlets or outlets. The second half of assumption 1 was also assured because rainbow trout do not reproduce in these lakes. If during the study the probability of death was equal for each fish then the abundance estimate was germane to the first event. To minimize the likelihood of higher mortality rates for marked fish, all captured fish were handled carefully and any fish that showed signs of severe stress was marked by excising a small portion of a fin that was not used to identify capture method prior to release. Any fish given such a mark was not considered part of the mark-recapture experiment. A hiatus of at least ten days should have been sufficiently long to minimize the effect of previous capture on capture probability as related to assumption 3. Validity of assumptions 2 and 3, relative to sampling induced selectivity of fish, was tested with either Kolmogorov-Smirnov (K-S) or Chi-squared (contingency table) tests generated from length data collected during the marking and recapture events (Appendix C). A length frequency histogram was used to distinguish size classes.

The first hypothesis tested was that all marked rainbow trout have the same probability of capture in the recapture sample (Event 2). Probability of capture usually differs by the size of rainbow trout, especially when a size selective gear was used. Fyke nets should not be size selective, however, they were typically placed near shore in shallow water where part of the population may not frequent. Given this situation the probability of capture will not be the same for all fish. If this test was significant, the recapture sample was biased and the data were partitioned into size classes. Population estimates were generated for each size class and these independent estimates were summed to estimate the abundance of the entire population. If the test did not detect a significant difference, the data were not partitioned and a single population estimate sufficed.

-continued-

The second hypothesis tested was that rainbow trout captured during the first event had the same length frequency distribution as fish captured in the second event. There were four possible outcomes of these two tests; either one or both of the samples were biased or neither were biased. Possible actions for data analysis were outlined in Appendix C.

Assumption 4 was assured because there was not sufficient time for excised tissue to grow back.

Assumption 5 was assured because of rigorous examination of all fish for fin clips.

Complete mixing of marked and unmarked rainbow trout between the first and second events was assumed to occur during the experiment. To promote mixing and give each fish an equal chance of being captured there was a hiatus of at least 10 days between the first and second events, and fish handled during all events were released toward the middle of the lake.

APPENDIX C
METHODOLOGIES FOR ALLEVIATING BIAS DUE TO GEAR SELECTIVITY BY MEANS OF STATISTICAL INFERENCE

Appendix C.-Methodologies for alleviating bias due to gear selectivity by means of statistical inference.

Result of first K-S (or χ^2) test[a]	Result of second K-S (or χ^2) test[b]
Case I[c]	
Fail to reject H_o	Fail to reject H_o
Inferred cause: There was no size-selectivity during either sampling event.	
Case II[d]	
Fail to reject H_o	Reject H_o
Inferred cause: There was no size-selectivity during the second sampling event, but there was during the first sampling event.	
Case III[e]	
Reject H_o	Fail to reject H_o
Inferred cause: There was size-selectivity during both sampling events.	
Case IV[f]	
Reject H_o	Reject H_o
Inferred cause: There was size-selectivity during the second sampling event; the status of size-selectivity during the first event was unknown.	

[a] The first χ^2 test was based on a contingency table to examine the effect of variable catchability of marked fish captured during the second event for various size/age categories. The contingency table was made up of marked fish from the first event that were re-captured and not re-captured in the second event. H_o for this test was: The probability of capture in the second event for marked fish was constant across the various categories.

or

The first K-S (Kolmogorov-Smirnov) test was on the lengths of fish marked during the first event versus the lengths of fish recaptured during the second event. H_o for this test was: The distribution of lengths of fish sampled during the first event was the same as the distribution of lengths of fish recaptured during the second event.

[b] The second χ^2 test was based on a contingency table to examine the effect of variable catchability in the first event for given size/age categories. The contingency table was made up of marked and unmarked fish captured in the second event. H_o for this test was: The probability of capture in the first event was constant across the various categories.

or

The second K-S test was on the lengths of fish marked during the first event versus the lengths of fish captured during the second event. H_o for this test was: The distribution of lengths of fish sampled during the first event was the same as the distribution of lengths of fish sampled during the second event.

[c] Case I: Calculate one unstratified abundance estimate, and pool lengths and ages from both sampling events for size and age composition estimates.

[d] Case II: Calculate one unstratified abundance estimate, and only use lengths and ages from the second sampling event to estimate size and age composition.

[e] Case III: Completely stratify both sampling events and estimate abundance for each stratum. Add abundance estimates across strata. Pool lengths and ages from both sampling events and adjust composition estimates for differential capture probabilities.

[f] Case IV: Completely stratify both sampling events and estimate abundance for each stratum. Add abundance estimates across strata. Also calculate a single abundance estimate without stratification.

If stratified and unstratified estimates were dissimilar, discard unstratified estimate and use lengths and ages from second event and adjust these estimates for differential capture probabilities.

If stratified and unstratified estimates were similar, discard estimate with largest variance. Use lengths and ages from first sampling event to directly estimate size and age compositions.

Testing of assumptions necessary for accurate abundance estimation may also reveal biases in age and size composition samples. Because age and length information were collected during mark-recapture sampling, bias in mark-recapture samples also indicates bias in age and size data that were collected. Age and size composition were used to apportion the population estimate into age classes or size categories, so that age and length information collected during either the marking sample, the recapture sample, or both samples may be used to calculate age and size composition.

If case I was indicated by tests (Appendix B), no adjustments to age and size data were necessary and data from both events may be pooled. If case II occurs, age and size data from the second event must be used to estimate compositions. If the population was closed between sampling events the abundance estimate was germane to both sampling events. For these two scenarios the proportion of fish at age was calculated as:

$$\hat{p}_i = \frac{y_i}{n} \tag{1}$$

where: $\hat{p}_i =$ the proportion of rainbow trout that were age i; y_i = the number of rainbow trout sampled that were age i; and, n = the total number of rainbow trout sampled.

The unbiased variance of this proportion was estimated as:

$$\hat{V}\left[\hat{p}_i\right] = \frac{\hat{p}_i\left(1-\hat{p}_i\right)}{n-1} \tag{2}$$

Size composition was estimated in a similar manner, replacing age class with the two size categories (less than 355 mm and 355 mm or larger).

If case III or case IV from inference testing occurs, either the first and second events were biased or the second event was unbiased and the status of the first event was unknown. If case III occurs, age and size data from both events can be pooled and adjustments made to these data. If case IV occurs and the partitioned and un-partitioned abundance estimates were dissimilar, age and size data from the second event must be used to estimate compositions. These data must also be adjusted for bias due to size-selectivity. To adjust age and size data, the proportion of fish at age was calculated by summing independent abundances for each age or size class and then dividing by the summed abundances for all age or size classes. First the conditional proportions from the sample were calculated:

$$\hat{p}_{ji} = {n_{ji}}/{n_j} \tag{3}$$

where: n_j = the number sampled from size class j in the mark-recapture experiment; n_{ji} = the number sampled from size class j that were age i; and, $\hat{p}_{ji} =$ the estimated proportion of age i fish in size class j. The variance calculation for $\hat{p}_{ji}$ was identical to equation 6 (with appropriate substitutions).

-continued-

The estimated abundance of age *i* fish in the population was then:

$$\hat{N}_i = \sum_{j=1}^{s} \hat{p}_{ji} \hat{N}_j \tag{4}$$

where: N_i = the estimated abundance in size class *j* and s = the number of size classes.

The variance for $\hat{N}_i$ in this case was approximated by the delta method (Seber 1982):

$$\hat{V}\left[\hat{N}_i\right] = \sum_{j=1}^{s} \left(\hat{V}\left[\hat{p}_{ji}\right] \hat{N}_j^2 + V\left[\hat{N}_j\right] \hat{p}_{ji}^2 \right) \tag{5}$$

The estimated proportion of the population that were age *i* $(\hat{p}_i)$ was then:

$$\hat{p}_i = \hat{N}_i \big/ \hat{N} \tag{6}$$

where: $\hat{N} = \sum_{j=1}^{s} \hat{N}_j$

Variance of the estimated proportion can be approximated with the delta method (Seber 1982):

$$\hat{V}\left[\hat{p}_i\right] \approx \sum_{j=1}^{s} \left\{ \left(\frac{\hat{N}_j}{\hat{N}} \right)^2 \hat{V}\left[\hat{p}_i\right] \right\} + \frac{\sum_{j=1}^{s} \left\{ V\left[\hat{N}_j\right] \left(\hat{p}_{ji} - \hat{p}_i\right)^2 \right\}}{\hat{N}^2} \tag{7}$$

APPENDIX D
ARCHIVE FILES FOR DATA COLLECTED DURING STUDIES COVERED IN THIS REPORT

Appendix D.-Archive files for data collected during studies covered in this report.

<table>
<tr><th>File Name</th><th>Description</th></tr>
<tr><td>u-040800r012000</td><td>Data from mark-recapture experiment at Dune Lake</td></tr>
<tr><td>u-040800r022000</td><td>Data from mark-recapture experiment at Dune Lake</td></tr>
<tr><td>u-013200|012000</td><td>Data from mark-recapture experiment at Bluff Cabin Lake</td></tr>
<tr><td>u-013200r012000</td><td>Data from mark-recapture experiment at Bluff Cabin Lake</td></tr>
<tr><td>u-015900r012000</td><td>Data from mark-recapture experiment at Donna Lake</td></tr>
<tr><td>u-015900r022000</td><td>Data from mark-recapture experiment at Donna Lake</td></tr>
<tr><td>u-041900r012000</td><td>Data from mark-recapture experiment at Little Donna Lake</td></tr>
<tr><td>u-041900r022000</td><td>Data from mark-recapture experiment at Little Donna Lake</td></tr>
</table>

Data files are available from the Alaska Department of Fish and Game, Sport Fish Division, Research and Technical Services, 333 Raspberry Road, Anchorage, Alaska, 99518-1599.